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OBSERVATIONS OF THE IMPROVEMENT IN VISION BROUGHT ABOUT BY THE APPLICATION OF A RAIN-REPELLENT LACQUER ON AN AIRPLANE WINDSHIELD

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INTRODUCTION

A rain-repellent lacquer was submitted to the National Advisory Committee for Aeronautics by Captain K. H. Kalberer, of Lorr Laboratories, and preliminary tests and observations have been made to determine its value in improving the vision through an airplane windshield during rain. The tests and observations were carried out at Ames Aeronautical Laboratory, Moffett Field, California, over a period of about a week. The results are reported herein.

DESCRIPTION OF THE LACQUER

The lacquer when applied consisted of a very thin, transparent film that could be distinguished with difficulty on a glass surface. It was apparent, however, to the touch and, when light struck it at a certain angle, slight interference refraction appeared in the reflected light. When looking through glass to which the lacquer had been applied, a line of demarcation was apparent at the edge of the lacquer when the glass was carefully scrutinized. The lacquer, when properly applied, did not appear to cause halation, increased reflection, or interfere with vision in any respect.

The action of the lacquer appeared to be that of a water-repellent or anti-wetting agent. This action was very apparent when a small drop of water was placed on a flat surface of a partially lacquered glass pane. The water on the unlacquered portion displayed a considerable wetting or spreading action, whereas the water on the lacquered part exhibited considerably greater cohesive action. When the flat plate was tilted, the water ran off the lacquered part at an angle smaller than that at which it ran off the unlacquered part. When attempts were made to run water from the unlacquered to the lacquered part of

the glass, it tended to gather at the edge of the lacquered portion and only after considerable tilt was given to the glass pane would the water run onto the lacquered part. It then ran over it in the form of small rivulets rather than as a sheet as it did on the unlacquered part. As a generalization, it may be said that the action of the water on the lacquered surface was similar to that of mercury on glass.

The application of the lacquer to glass involved several steps. Two separate solutions were mixed together and the resultant solution was applied within a day. (It became cloudy and was no longer useful for the intended purpose if allowed to stand longer. However, recent experiments making use of one solution alone were reported as successful.) The glass to which the lacquer was applied was warmed to a temperature of about 110° F. (The heating may be accomplished by the use of a hot plate, heating pad, or hot-air blower.) If the glass was not warmed, the drying of the lacquer took considerably longer and halation also occurred, which was not present in the lacquer applied on warm glass. The lacquer dried in about one hour when applied to warm glass. It was applied in one stroke of a saturated pad which had been bent around the straight edge of a piece of glass. It appeared that the use of a heating pad would permit the lacquer to be applied on glass windshields that are not removable from the airplane. Although most of the observations were made with the lacquer applied on glass, observations were also made with the lacquer applied on plexiglas. Its action on plexiglas was identical with that on glass and in no way did the lacquer appear to adversely affect the surface of the plexiglas.

The lacquer suffered from the accumulation of dust and dirt as much as any glass surface. It is thought that the removal of dirt from the lacquered surface may be somewhat of a problem as the lacquered surface was easily marred. The durability of the lacquer with respect to the action of sunlight, heat, salt-water spray, and general service use was not studied.

TESTS, RESULTS, AND DISCUSSION

All tests and observations were made on a Lockheed 12A airplane NC-17397 furnished by the Lorr Laboratories. Tests and observations were made on the ground and in actual flight.

Ground Tests

The apparatus used in the test demonstration on the ground is shown in figure 1. Water from an ordinary garden hose and nozzle was sprayed on the windshield in the direction of the line of flight. As a movement of air across the lacquered surface is necessary to obtain an action such as the water droplets would exhibit in actual flight in rain, a wind was simulated by a vacuum-cleaner blower fitted with a nozzle which was directed on the windshield as shown in figure 1. The resultant action of water on the windshield was then very similar to that obtained in actual flight in heavy rain. Figure 2 is a photograph of a view through the windshield toward some hangar doors when the set-up shown in figure 1 was used to spray the windshield. The improvement of vision created by the application of lacquer is very evident. The lacquered portion of the windshield consisted of a horizontal strip through the center of the windshield, the upper and lower portions of the windshield being unlacquered. It is readily seen that the water spray on the unlacquered portion creates in effect a sheet of water through which vision is impossible, whereas vision through the lacquered portion is almost as good as that through a dry windshield. Water droplets may be seen to be moving off the lacquered portion in a horizontal direction under the influence of the spray and air movement. This is similar to the movement of the water droplets across the windshield during actual flight, except that in actual flight the droplets are broken up into a finer spray. The water particles moved much more rapidly across the lacquered portion of the glass than across the unlacquered portion, and again may be said to resemble the movement of mercury on glass.

Flight Tests

For the purpose of obtaining comparative data in actual flight conditions, several flights were made in rain of varying degrees of intensity. During these flights the Committee's pilots acted alternately as pilot and co-pilot, and were able to clearly observe the comparative action of the rain on both the treated and the untreated surfaces of the windshield and the resulting vision as afforded through the respective surfaces. Owing to the difficulty of obtaining proper lighting conditions and a background which would permit vision through the windshield to be demonstrated, pictures taken in flight failed to reveal the action of the lacquer.

As practically all flights were made in rain at an altitude of less than 1000 feet, due to the low ceiling that prevailed in the storm area, the pilots concentrated chiefly on noting the comparative degree of vision and visibility range in the directions forward and down, as obtained between the normal windshield surface and the surface that had been treated for rain repellence.

As the tests progressed, it soon became evident that the treated surfaces permitted vision to be obtained under the most unfavorable conditions that could be imposed. While no record of the amount of rainfall was made during the intervals of exposed flight, it was estimated that the heaviest rain condition experienced limited the outside visibility forward and down to less than one-half mile. It was learned later that autoists, driving under the general area in which the airplane was being flown, had frequently been forced to stop during the heaviest downfall owing to their inability to see through car windshields even with wipers working.

The flight tests showed that vision through the untreated windshield was poor in the mildest rain showers and decreased rapidly as rain intensity increased until it became completely obscured. At the same time vision through the treated windshield still permitted forward visibility over a range of about one and one-half to two miles.

A description of the comparative effect of rain on the treated and the untreated surfaces in flight may be of interest. The two outstanding characteristics that varied noticeably on the two different surfaces were the physical appearance of the rain water on the surfaces and the difference in the relative motion of the surface water on the untreated and the treated surfaces as imparted by the relative wind past the windshield.

On the untreated windshield the rain struck the surface and appeared to be retained thereon in numerous splotchy formations; whereas on the treated windshield, the rain, upon contacting the surface, appeared to break up into numerous small globules which, owing to apparent lack of adhesion to the surface and to their rounded shape, had very small contact area.

The relative wind on the untreated surface water imparted a comparatively slow motion to the adhering water

splotches, carrying them across the windshield surface in irregular but numerous close formations; the water splotches in the meantime, having considerable adhesion, were elongated by their motion, thus tending to increase the wetted area still further.

Under the same conditions of exposure, the relative wind imparted a much faster motion to the rain globules on the treated surface. In fact, the speed at which the small globules of water were carried across the windshield surface was so high, it is suspected that a goodly percentage of water particles were lifted from the windshield surface and carried parallel to it.

DISCUSSION

The practicability of utilizing this lacquer will depend, no doubt, upon several factors other than its ability to improve vision. These are listed as follows:

1. Need for improved vision in heavy rain.

2. Durability of the lacquer in general service use, which, in turn, would depend upon its resistance to such items as sunlight, heat, abrasion, age, water, and salt water.

3. Ease and cost of application.

The preliminary investigations as reported herein are too incomplete to make possible the weighing of the advantages and disadvantages of the use of the lacquer. It would appear, however, to be decidedly valuable for the improvement of vision through airplane windshields, plexiglas bombing windows, machine-gun station, hoods, and so forth, on military aircraft.

It is possible that further development work can improve the durability of the lacquer to such an extent that it will have possibilities for use on such things as seaplane-float bottoms, automobile windshields, and any surface upon which a water-repellent action is desired or through which improvement of vision is desired in rain or water spray.

CONCLUSIONS

The lacquer definitely made vision possible in rain or water-spray conditions in which it would otherwise be impossible, and it appears to be of value from a military standpoint in improving vision of pilots, gunners, and bombers from an airplane during flight in rain. It appears to have possibilities for numerous other applications - its value for these applications apparently being dependent upon its durability under various service conditions. The durability of the lacquer has yet to be thoroughly tested, although it appears good enough at present for certain uses when reapplication of the lacquer can be made from time to time.

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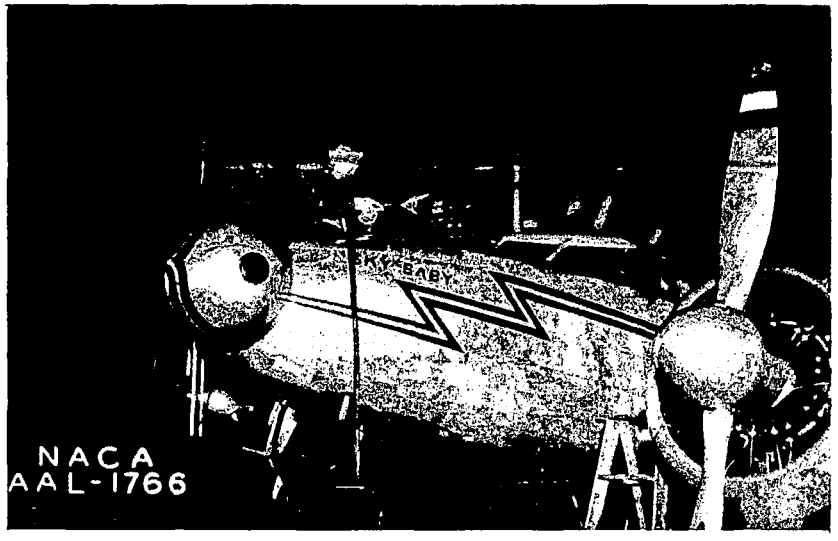

Figure 1.- Lockheed 12A. NC-17397. (Lorr Laboratories). Ground test set-up used to demonstrate rain-repellent application on windshield.

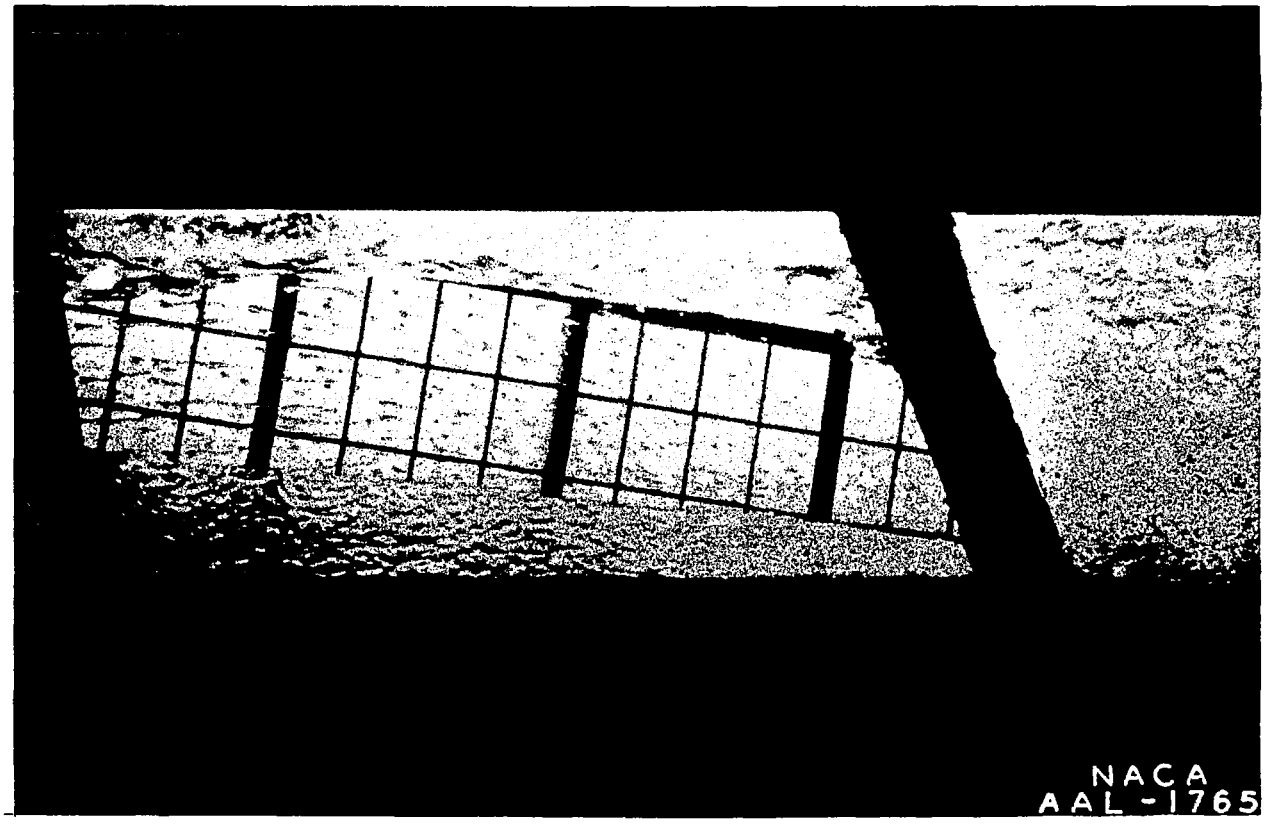

Figure 2.- Lockheed 12A. NC-17397. (Lorr Laboratories). Ground test of rain-repellent application on windshield.